Bell and Gray: Contrasts in Style, Politics, and Etiquette

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Abstract—In the late 1870's both Alexander Graham Bell and Elisha Gray claimed to be "the inventor" of the telephone. Both held substantial claims to this title. Yet, conventional folk wisdom tells us that Bell invented the telephone. This paper explores one reason for this outcome: the difference in the style of invention between Bell, a professional speech teacher, and Gray, a professional inventor. Just as style is crucial in the success of an author or an artist, style is also critical in an inventor's success. Central to this study of the differences in Bell's and Gray's style is the element of science. The two inventors saw science in very different ways. Thinking that the electrical transmission of speech was more a matter of interest to the scientific community than the technical community, Gray chose not to develop his mature ideas on how this could be accomplished. Bell, on the other hand, saw great commercial possibilities in the telephone. In developing the device, Bell not only applied what science he knew, he also used the scientific community to establish priority for his invention and to provide expert witnesses for his ideas. He achieved success in this regard because he understood the norms of science in America and followed them with perfect etiquette.

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I

ONE HUNDRED YEARS ago on a hot sweltering Sunday in Philadelphia, Alexander Graham Bell demonstrated a pair of magneto telephones to a group of Centennial Exhibition awards judges including the famous British scientist Sir William Thomson and several American scientists. There in the quietness of the deserted exhibit hall Bell explained his devices and then talked over them to Sir William and to the Centennial Exhibition's special guest of honor, Dom Pedro, Emperor of Brazil. Both men marveled. Dom Pedro saw in Bell's demonstration much of the same ingenuity he had seen in all the displays of American technology such as the giant Corliss engine and the Wallace–Farmer electric arc light system.

Sir William appreciated the ingenuity too, but this great scientist could also find beauty in the simplicity of Bell's telephone, in the way it demonstrated scientific principles that had not been entirely clear in the past. Bell's Centennial telephone demonstration can only be viewed as one of the great moments in the history of electrical communications.[1]

Yet, while this moment was charged with the heroic and the scientific, there followed a heated battle over the question of who "really" invented the telephone. A number of inventors found supporters for their claims; for some, these were very substantial. Charges and countercharges, suits and countersuits, accusations and name-calling ensued. Indeed, even today the controversy is occasionally reopened by historians and journalists.

Nothing can be settled and little can be learned through attempts to dethrone Bell and stake a claim for some inventor long forgotten. Bell will remain "the inventor" of the telephone in the public mind. Nevertheless, the controversy surrounding the invention of the telephone offers us a splendid opportunity to explore technological progress in broad human dimensions.

Inventors and engineers ply their craft with individual and distinctive styles, just as musicians, artists, and writers do. Education, intelligence, and personality strongly shape an inventor's style, which is made up of numerous components: idea generation, research, experimentation, correspondence, publishing, patenting, and business and legal pursuits come quickly to mind. These elements of style often prove to be crucial in the success of an inventor and his inventions. Bell's demonstration at the Centennial Exhibition shows this quite clearly. He aimed it not merely at a popular audience (at Dom Pedro, say) who would marvel at the telephone's ingenuity, he also sought to impress the scientific community (of which Sir William was a leading spokesman) by demonstrating his comprehension of the physical phenomena attending telephonic transmission. In this case, not only Bell's aspirations but also his abilities and attention to what might be called "scientific etiquette" helped determine subsequent events. Several other episodes in Bell's life between 1874 and 1879, the critical years in the invention of the telephone, reveal the importance of his style. In retrospect, we can point to this as a critical factor in his victory regarding priority, something that becomes even more clear when we compare and contrast Bell's style with that of the most important of the other claimants, Elisha Gray. In doing so in the following pages, we will examine the invention of the telephone in a new light, one which holds important ramifications for the general process of invention and innovation.

II

The telephone was an off-shoot of a particular technical problem that the telegraph industry faced in trying to expand its message-carrying capacity without investing substantially more capital. From the telegraph's introduction in 1844 until the end of the Civil War, the industry had put up over 80 000 km of wire for its 47 000 km of lines. During the decade that followed the war, these figures quadrupled; in the Centennial year, 400 000 km of wire were used for 178 000 km of line.[2] The ratio of wire to line promised to climb sharply as pressure grew for more capacity on existing lines. As in most industries, the Depression of 1873 stimulated the telegraph industry to search for new ways to economize. The industry's leaders, its trade journalists, and its technical experts all seemed to agree on one solution: multiple transmission of messages.

Until 1872, when Western Union introduced Joseph Stearns' duplex system, each set of telegraph instruments—transmitter and receiver—required a separate wire to carry out a single message transmission because the telegraph operated using intermittent dc signals. Each time the industry wanted to expand its capacity between any two existing stations, it had to add another wire. In today's language, each additional channel required another wire. It became obvious that expansion in this way would soon become unfeasible as costs became crucial and as telegraph wires threatened to weave a black veil above city streets. Multiple telegraphy, if it could be developed, offered a tremendous solution to these problems. Multiplexing would allow the industry to expand its capacity without requiring a huge investment of capital. The Stearns duplex of 1872, an intermittent current system which allowed one message to be transmitted simultaneously from each end of the wire, showed great promise and indeed Western Union paid handsomely for it.[3] To the inventor who could make a telegraph wire carry four or eight simultaneous messages, however, even greater rewards were promised.

Seeking these rewards, Elisha Gray, a professional inventor from Chicago, and Alexander Graham Bell, a young professor of elocution recently moved to Boston, entered the contest to develop a multiple telegraph. Working independently, Gray and Bell each departed from standard practice into a new world of the frequency spectrum, and, in working with multiple telegraphy, each hit upon the idea of speech transmission.

III

Twenty-four year old Alexander Graham Bell arrived in Boston in early spring 1871 to accept a teaching appointment at the School for Deaf Mutes that his father, Alexander Melville Bell, had secured for him. The elder Bell, former Professor of Elocution at the University of Edinburgh and a recent immigrant to Canada, had achieved an international reputation for his system of Visible Speech, a method of teaching the deaf to speak. Now, the younger Bell set as his goal not only the teaching of the deaf but also bringing about widespread adoption of his father's system.

Bell's family- and personal-history in retrospect appears as a definite clue that he would invent a device for the electrical transmission of speech. His father and grandfather had equipped him with extensive knowledge of the physiology and mechanism of human speech and they had instilled in him an intense desire to learn more about the phenomena of sound. Four years earlier, from experiments with tuning forks, young Bell had developed a theory of vowel tones, which he divulged to the well-known English phonetician Alexander Ellis. While im-

[1] For more information on this demonstration of June 25, 1876, see R. V. Bruce, *Bell: Alexander Graham Bell and the Conquest of Solitude*. Boston: Little, Brown and Company, 1973, pp. 188–198. I must note that in sections of this paper dealing with Alexander Graham Bell, I have relied heavily upon Robert V. Bruce's solid biography of Bell for factual information about Bell and his work. The Bell manuscripts are now preserved by the Library of Congress and are open to scholars. Professor Bruce's work has given me guidance in using these manuscripts and has also pointed me to other manuscript collections. The published and unpublished work of Bernard S. Finn has also been invaluable in regard to Bell manuscripts. In quoting from Bell manuscripts, I have cited Bruce's book in instances where he also quoted these same passages. Readers are encouraged to study the Bell biography for Bruce's interpretation of this highly complex individual.

[2] Anonymous, "Telegraph Progress," *J. Telegraph*, vol. 14, p. 181, June 16, 1881.

[3] G. B. Prescott, *Electricity and the Electric Telegraph*. New York: Appleton, 1882, pp. 792–809.

pressed with Bell's work, Ellis informed him that he had been following the footsteps of the German physicist Herman von Helmholtz. Although disappointed by his failure of priority, Bell soon found an opportunity to talk at length with Ellis about Helmholtz's work. Ellis translated for Bell many of the passages from Helmholtz's *Die Lehre von den Tonempfindunggen* and tried to explain the electric tuning fork apparatus that Helmholtz had devised for his experimental work.[4] When the Bells emigrated to America in 1870, young Bell carried with him a French translation of Helmholtz, which he read and contemplated during the next few years. Helmholtz's experimental apparatus would provide the basis for Bell's future work in multiple telegraphy. Thus Bell brought to Boston rich training in speech and a gentleman's understanding of Helmholtz, but in addition, his father's high status in the Boston–Cambridge intellectual community adhered to him. Already this had been important in the Old World where the Bells had mingled with men such as Charles Wheatstone, George Bernard Shaw, and James Murray (the creator of the great *Oxford English Dictionary*). This status guaranteed Bell access to the best minds of the New World, minds that would give him both ideas and encouragement. Coupled with his solid education and impressive status, Bell also seemed possessed by a zestful desire for fame and fortune.

On his first day in Boston, he visited Lewis Monroe, Professor of Elocution at M.I.T. and his father's friend. Their discussion focused on the science of sound; Monroe's understanding of Helmholtz gave Bell a new perspective on the science, as did Monroe's reports on John Tyndall's new book on sound. Monroe informed Bell that M.I.T. owned a set of Helmholtz's apparatus and promised to repeat the physicist's experiments. With the excitement of this news, Bell could hardly wait "to devour" Tyndall's new book, which Monroe kindly gave him.[5] Thus while Bell launched his career in Boston as a teacher of the deaf, he also initiated his investigation of the science of sound, which would lead him into contact with a group of men who were vigorously pursuing the study and promotion of that science.

Bell met with great success in his teaching in 1871, and during 1872 he began reaping some rewards. He published several articles on Visible Speech in periodicals such as *American Annals of the Deaf and Dumb*, *Springfield Republican*, *The Congregationalist*, and *Old and New*. Schools throughout New England invited him to lecture. His reputation quickly grew because of his "kindness, cheerfulness, and earnestness" and because his training in elocution made his own delivery impressive in itself.[6] Riding high on his success in teaching and speaking, Bell also found exhilaration in science. He heard John Tyndall lecture on the undulatory theory of light at the Lowell Lectures of 1872, and he attended the M.I.T.–Lowell Institute lectures on zoology, geology, and experimental mechanics. Charles R. Cross, the assistant to M.I.T. physicist Edward C. Pickering, delivered the lectures on experimental mechanics.[7]

In the late fall of 1872, a newspaper account of Western Union's adoption of the Stearns duplex telegraph captivated Bell.[8] The article revealed the importance of the duplex telegraph, and, to one who sought fame and fortune, it became clear that by making a telegraph transmit four, eight, or even more simultaneous messages, fortune if not fame could be quickly achieved. Toward this end, Bell set out in November 1872.

As noted, Helmholtz's experimental apparatus provided the basis for Bell's telegraph. He envisioned using a number of tuning forks or vibrating reeds, each tuned to a different note, to generate sinusoidal currents. Each frequency of current, he thought, could be used to carry individual telegraph messages that would be put onto the same wire. From his experience in sound, he reasoned that the number of transmitted messages was limited only by the number of notes in the diatonic scale. Receiving these messages presented the most difficulty; Bell thought that by tuning receiving reeds to each transmitted frequency, each receiver would respond only to one frequency of transmitted message. Thus Bell appreciated the fact that currents of various frequencies can be combined into a composite waveform and then filtered out again into the individual input frequencies. To achieve practical results, however, Bell believed that he needed more understanding of acoustics and of electricity. Further study of Helmholtz and Tyndall on sound and Tyndall's work on electricity helped; perhaps more important, Bell's growing intimacy with the local scientific community provided key information.

Bell's teaching activities consumed most of 1873 and prohibited him from perfecting his multiple telegraph. During this year, he had been appointed to the new position of Professor of Vocal Physiology and Elocution at Boston University, and, while this job demanded new responsibilities, Bell found great benefit for the prestige embodied in the title "Professor."[9] In January 1874, after organizing a highly successful Visible Speech convention in Worcester, he gave a lecture on Visible Speech at M.I.T.'s Society of Arts and Science, which some 400 people attended. The success of that lecture, he reported to his parents, "has at once placed me in a *new position* in Boston. It has brought me into contact with the *scientific minds* of the city." This included "free access to the Institute of Technology—and permission to experiment with Helmholtz' apparatus and with Scott and Koenig's 'Phonautograph' and Revolving Mirror Apparatus."[10] Professor Bell did not let this opportuniy slip through his hands. Soon he was carrying out joint experiments with Charles Cross at M.I.T. and with Clarence J. Blake, a Boston ear specialist and Lecturer on Otology at Harvard University Medical School.[11] These experiments and the scientific spirit with which they were carried on impressed Bell, but while he was away for the summer, Blake wrote a letter to another American experimenter about his recent work in acoustics:

> I have just learned of your experiments on telegraphic transmission of musical tones and shall be much interested to learn more thereof as I have been lately experimenting in connection with Prof. A. Graham Bell on the phonautographic valve of consonant and vowel sounds as received and transmitted by the drum membrane of the human ear. In your own further experiments it may be of value to you to know of the late work by Prof.

[4] A. G. Bell, "Researches in electric telephony," *J. Society of Telegraph Engineers*, vol. 6, pp. 385–421. See also Bruce, *Bell*, pp. 47–48, 51.

[5] Bruce, *Bell*, pp. 75–76.

[6] *Silent World*, Aug. 1, 1872, pp. 7–8. Cited from Bruce, *Bell*, p. 88.

[7] Bruce, *Bell*, pp. 81–93. Cross would later gain fame as a skilled experimentalist.

[8] Boston *Transcript*, Oct. 18, 1872. Cited from Bruce, *Bell*, p. 93.

[9] Bell received the job offer from Lewis Monroe, the dean of Boston University's new School of Oratory. Bruce, *Bell*, p. 98.

[10] Alexander Graham Bell to his parents, ca. April 9, 1874, Bell MSS., L.C. Bruce, *Bell*, pp. 110, 112.

[11] Bruce, *Bell*, pp. 110, 112.

> Wolf entitled "Speech and the Ear" and if our experiments this autumn proving successful shall be happy to place the results at your disposal and should in return be obliged for any further information which you may be pleased to give me concerning your own investigations.[12]

The experimenter replied:

> I am engaged at present with Professor Tyndall and Latimer Clark in conducting some experiments partly as a matter of scientific interest, and partly with a view of certain practical applications.[13]

He added that he would indeed like to exchange information, and after receiving this reply, Blake wrote Bell:

> I have received a letter from the Royal Institute from Elisha Gray, concerning his experiments in telegraphing vocal sounds, which you will be glad to see.[14]

This brief communication upset Bell greatly. It caused him to confront—at least partially—a dilemma in which he had found himself for some time. The experiments with Cross and Blake had been carried out with the assumption—at least by Cross and Blake—that they were scientific; this meant free exchange of ideas in the hopes of expanding the frontiers of science. Although Bell may have thought he had been abiding by the unwritten rules of scientific collaborative inquiry, he had also been consciously or unconsciously witholding some of his ideas, which, while they related more directly to multiple telegraphy, also impinged on acoustics and electroacoustics. With regard to multiple telegraphy, Bell had bound himself to almost total secrecy. He worried so that someone might steal his ideas that he had bought a special table with a locked cover in which he could hide his apparatus—in his own house.[15] Now, Blake's invitation to Gray and to Bell for the mutual exchange of information—all for the good of science—threatened Bell's hopes for attaining fortune through his work. A day after receiving Blake's note, Bell paid him a visit and told his co-experimenter that he would not read or hear about Gray's letter because he did not want to be accused of taking Gray's ideas. He went on to confess that his work in acoustics and his secret experiments in multiple telegraphy had led him to the idea of transmitting speech electrically. He sketched out for Blake his ideas of a telephone transmitter and receiver, which Blake thought feasible. And, at that point, Bell and Blake more or less ended their acoustical partnership.[16] Long before, in choosing secrecy, Bell had decided against collaboration with the multiple telegraph and now he ruled out collaboration, whether it be called scientific or technological, on the telephone. At that moment, ideas for a multiple telegraph and a telephone filled Bell's mind, but he had not reduced either to practice. What had Elisha Gray accomplished?

IV

When Elisha Gray answered Clarence Blake's letter he was in London, as he said, at the Royal Institution carrying out experiments with John Tyndall, Michael Faraday's student and successor, and Latimer Clark, perhaps the greatest figure in British telegraphy.[17] Early in the year of 1874, he had discovered—by accident—that currents from an induction coil could be received as musical tones by dry animal tissue in rubbing contact with a metallic conductor (for instance, a hand move along a piece of zinc). Experimenting with this phenomenon further, he discovered that he could receive chord-like or composite tones when he put two currents of different frequencies onto the same wire.

Until the spring of 1874, Gray had been superintendent and co-founder of Western Electric Manufacturing Company. In 1867, he had patented his first telegraphic invention and its remarkable success helped him buy a partnership in a small telegraphic manufacturing shop in Cleveland. Gray continued to invent, and, through the success of his inventions such as an electric annunciator and a printing telegraph, the small firm of Gray and Barton grew in importance. In 1872, Western Union purchased one-third of the company, now moved to Chicago. Under a new name, Western Electric Manufacturing Company, the firm rapidly became the largest telegraph and electrical manufacturing enterprise in the United States. As superintendent, Gray continued his pattern of successful inventions, but his discovery of 1874 appeared so revolutionary that in the spring he resigned (although he remained on Western Electric's board of directors) to pursue full-time independent invention.

From April until August, Gray vigorously investigated the phenomena of "vibratory currents," as he called them. He developed several types of receivers (including electromagnetic ones with metallic diaphragms) and he also designed transmitters, which he called single-tone transmitters and which produced better waveforms. Because he had found "that not only simple, but composite tones could be sent through the wire and received," Gray concluded that musical telegraphy, multiple telegraphy, and the transmission of speech were all possible. He knew that his experimental apparatus could be connected without modification to form a simple musical telegraph system similar to today's electric organ. Like Bell's thinking in multiple telegraphy, Gray thought that each tone, or frequency, could be used to carry individual messages, but the problem in this lay in developing receivers to filter messages out of the composite waveform. Transmission of speech offered the opposite problem. Gray knew his electromagnet diaphragm receivers would reproduce any simple or compound signal. He lacked only a transmitter that would convert the human voice into the appropriate waveform.

Gray thought that his initial discovery and the developments it might spawn were of such commercial and scientific importance that he gave semi-public demonstrations in New York and in Washington. In May, Western Union officials in New York witnessed Gray's demonstration of the generation, transmission, and reception of vibratory currents. While much of the exhibition was devoted to musical telegraphy, Gray also discussed application to multiple telegraphy, and even the transmission of voices was mentioned. Gray chose a scientific audience in Washington. In June, he demonstrated his apparatus at the Smithsonian Institution to Joseph Henry and others. Although this audience differed greatly from that in New York, Gray's presentation remained roughly the same; he gave a brief history of his discovery and subsequent work

[12] Clarence J. Blake to Elisha Gray, Aug. 15, 1874, Gray MSS., Div. of Elec., National Museum of History and Technology.

[13] A. G. Bell, *The Bell Telephone: The Deposition of Alexander Graham Bell*. Boston: American Bell Telephone Company, 1908, p. 193.

[14] *Ibid.*

[15] Bruce, *Bell*, p. 94.

[16] A. G. Bell, *The Bell Telephone*, pp. 192–193. Bruce, *Bell*, pp. 128–129.

[17] The following six paragraphs are based on D. A. Hounshell, "Elisha Gray and the telephone: On the disadvantages of being an expert," *Technology and Culture*, vol. 16, pp. 133–161, Apr. 1975.

in his characteristically low-key, informal manner, demonstrated his apparatus, and suggested possibilities for their practical application. In regard to multiple telegraphy, for instance, he told the scientists that he soon planned to go to England to test the performance of sinusoidal currents under the attenuating effects of submarine cables. He saw that a multiple telegraph would not be eminently successful until it could overcome the problem of attenuation.

Gray's Washington demonstration, although noted as "very curious,"[18] failed to capture the scientific community's attention. Perhaps this was because he had not given a more formal presentation, or because he emphasized possible applications of his discoveries to an audience that took pride in being "pure" scientists, or even because he did not bear the cachet "Professor" Gray. More important, he chose not to write a scientific paper on the discovery and publish his findings in an appropriate journal of science. Notice, however, that Gray, although he made his living from his inventions, was open and honest about his discoveries and his ideas for the future. No doubt he had filed patent applications on some of his apparatus, but most of what he exhibited was strictly experimental; Gray, "one of the most ingenious practical electricians of this country," as Joseph Henry regarded him,[19] had made—unsuccessfully—a humble offering to the cause of science.

When Gray received the letter from Blake, he was, as he explained, partly on a scientific mission and partly on a practical pursuit. He demonstrated his experimental apparatus to Tyndall at the Royal Institution in London. It appears that the Tyndall–Gray meeting, like Gray's Washington meeting, was both uneventful and unrewarding. More important, he tested vibratory currents on submarine cables to see if attenuation effects would prohibit the use of his planned multiple telegraph on cable circuits. Thus when Gray wrote Blake, he had not perfected a multiple telegraph or a telephone. But he had made known publicly throughout the world that this was his intention, and he had shown his apparatus both to scientific and commercial audiences. Newspaper accounts documented these activities; this is how Blake first learned of Gray.[20]

V

Before either Bell or Gray had perfected a multiple telegraph or a telephone, therefore, one can already see a radical difference in their respective approaches to invention—in their styles. Bell approached the multiple telegraph and the telephone in absolute secrecy with a great knowledge of the phenomena of sound and almost no experience in electricity. Bell's oratorical ability, his bright and quick personality, his position of Professor of Elocution, and his understanding in acoustics helped gain for him support within the scientific community. His attendance at scientific lectures in the community gave him a feeling for many of the norms of science, and his impressive list of publications on Visible Speech and related topics equipped him with critical skills that he would use for the last stage of Michael Faraday's famous dictum, "work, finish, publish." Gray, on the other hand, worked in the open and from the approach of a practical electrician. It is doubtful whether he had read Helmholtz before he made his discovery, and, while he may have wished to be a member of the scientific community, the fact that he gained his livelihood from invention ruled this out. Gray's failure to publish his findings in 1874 also wrought problems that he would face in the future. Yet both Bell and Gray sought to invent a multiple telegraph for the same reason: money. As it turned out, Bell would pursue the invention of the telephone for this reason and for fame; Gray, on the other hand, would see the telephone only as a matter of scientific interest, and, perhaps because of his experience with the scientific community in 1874, he would give up any ambitions for scientific prestige.

VI

Until Blake informed Bell of Gray's "experiments in telegraphing vocal sounds," Bell had pursued the perfection of his multiple-telegraph scheme in a leisurely fashion and had merely reflected about voice transmission. Bell's fear of someone stealing his ideas significantly hampered his work; even with almost no mechanical skills or tools, he had decided to make his own apparatus and went so far as to wind his own coils.[21] As a result, what would have taken a skilled instrument maker a day or less to complete often consumed months of Bell's evening hours (the only time he could work on his inventions). But now with word that Elisha Gray was on the move, and under pressure from his new financial backer, Gardiner G. Hubbard, Bell broke down and consulted an experienced electrician who employed his own instrument maker. He did not choose just any electrician. He picked the one who, as he wrote his parents, was "as celebrated here as Wheatstone is at home"—Moses G. Farmer, inventor of the fire-alarm telegraph, codiscoverer of the dynamo principle, and a well-regarded electrical theorist.[22] Bell sketched out for Farmer his plan for a multiple telegraph and explained his theory. Farmer saw no problem in developing this plan and therefore delegated one of his assistants to work with Bell in the perfection process. Then Bell "ventured cautiously" in explaining to Farmer his ideas for voice communication. Bell wrote his parents about Farmer's response: "To my delight, he said the theory was *all right* but that to solve the difficulties of practically working the idea were such that it would take years to solve the problem practically. He advised me to publish the idea in the Philosophical Magazine after I had protected my [multiple] telegraphic scheme."[23] But somehow, the timing for publication just did not seem right to Bell.

Later Bell talked with his old research partner Charles Cross about his telephone idea. Being a careful and informed scientist, Cross told him that in 1861 a German named Philipp Reis had published an article on his "telephone" that had created quite a stir among men interested in acoustics and among instrument makers.[24] No doubt Cross also pointed out to Bell some of the recent articles published by a New York physician about this curious instrument that, it was claimed, could transmit music as well as vocal sounds. Bell therefore needed to do some homework on this matter before he could ever publish his ideas, especially since *The Telegrapher* had re-

[18] These were the words recorded by Frank W. Clarke, a young Washington scientist, in his diary entry of June 13, 1874. His diary is in the Library of Congress. Cited in Bruce, *Bell*, p. 113.

[19] Joseph Henry to John Tyndall, July 2, 1874, Gray MSS., Div. of Elec., NMHT.

[20] See, for example, New York *Times*, July 10, 1874.

[21] Bruce, *Bell*, p. 94.

[22] Alexander Graham Bell to his parents, November 16, 1874, Bell MSS., L.C. Bruce, *Bell*, p. 130.

[23] Alexander Graham Bell to his parents, November 23, 1874, Bell MSS., L.C. Bruce, *Bell*, p. 131.

[24] Bruce, *Bell*, p. 131.

cently pointed out the similarities between Gray's work and that of Reis.[25]

Somehow—most likely through his patent lawyer—Bell kept tabs on Gray's activities. This was not difficult since Gray had chosen to develop his system in the public eye. All of the Boston newspapers had, at one time or another, carried a story on Gray's work. Bell wrote his parents on November 23, 1874: "It is a neck and neck race between Mr. Gray and myself who shall complete our [multiple telegraph] apparatus first."[26] Conscious of an impending struggle with Gray, Bell began to marshal legal ammunition that might be used in a court battle. He wrote his parents regularly about his activities and requested that they save his letters for evidence.[27] He persuaded his neighbor, Percival Richards, almost the only witness to his telegraphic experiments of 1873, to record his memories of what he had seen Bell do in that year.[28] To his backer Hubbard, he began sending dated and signed progress reports on his experiments.[29] Later Hubbard advised him to take an extra precaution: to make it a practice to consult scientists regularly in order to have expert witnesses.[30] (Bell later confirmed that he had done this when in 1875 he wrote a family friend, who later bought his British patent rights, "I have only spoken of the matter to two or three scientific friends who have been assisting me with their advice.")[31]

Thus we see Bell working at the invention of both the multiple telegraph and the telephone along many fronts: hiring expert advice and skills in the person of Moses Farmer and his assistants; tapping the scientific brains of the Boston–Cambridge community while at the same time grooming them as future witnesses; launching a correspondence deliberately conceived to be used in court; keeping his fingers on the pulse of Elisha Gray's work; building up documentation on his early work through a friend's memory; and examining what had been achieved in the past. While he continued lecturing on Visible Speech and teaching private pupils and Boston University students, Bell was not only orchestrating what would come later, he was also directing the performance.

VII

Meanwhile, Elisha Gray had returned from Europe thoroughly convinced of the feasibility of his multiple-telegraph plan. During the fall and winter of 1874, he perfected his musical telegraph system and gave several public concerts. He also worked on the multiple telegraph, attempting to develop receiving filters and applying the entire idea of multiple telegraphy to the printing telegraph that had made him so well known as an inventor. Early in 1875, he applied for certain patents on the multiplex system, but then in a storm he wrote one of his patent lawyers:

> Do you know a professor Bell in Washington? Have you ever had any conversation with him in regard to my invention and what was the character of it? He claimed to [Western Union president William] Orton that he could antedate me in everything that I ever claimed to do. The coincidence was so remarkable that it looks suspicious.
>
> He told Orton not to tell him how I did what I claimed [in multiple telegraphy], but let him tell what he did. And then [he] went on and described my method in regard to printing and all. Now I want you to tell all you know for I suspect he never thought of the thing till he got it from my invention.[32]

Apparently Gray had not remembered that Clarence Blake had mentioned Bell's name in his August 15, 1874 letter. The letter, however, made no mention of Bell's work in telegraphy, since Bell had kept this secret, so there was little reason to remember. Somehow, Gray failed to realize that his public posture might have given another inventor plenty of ideas. This is not to imply that Bell took anything from Gray, but Gray's openness certainly gave Bell information that he and his lawyers could use for any future patent dispute or commercial venture.

Even though Gray was set back by a multiple-telegraph patent issued to Bell in April 1875, he continued to work on his multiplex system. By May he felt confident: "I am ready to show up my invention as far as I have gone, whenever Mr. Bell is. That is the only ground upon which a compromise can be reached. I am willing to let the thing rest upon its merits."[33] Yet this meeting never took place nor was a compromise ever reached.

Like Gray, Bell also felt confident. Patent matters had shaped up nicely while he was in Washington in March 1875, and, more important for his spirit, he had held a successful meeting with Joseph Henry.[34] Most accounts of Bell's invention of the telephone mention this historic meeting with American science's elder statesman, but few have understood it fully. Bell met with Henry not because he knew the most about electricity at that time (this would have been someone like Henry A. Rowland) but because he was *the* statesman of American science. Henry held the power to make or break a scientist's reputation and to boost or censure an inventor. Bell sought the elder's scientific endorsement for his multiple-telegraph scheme, for his telephone idea, and for himself. In this meeting, he recounted his experiments in sound and electricity, described his multiple-telegraph plan, and outlined his untried ideas about voice transmission. In connection with the latter, Bell asked Henry whether he should publish his untried ideas in a scientific journal, letting others pursue the problem, "or attempt to solve the problem myself."[35] Henry advised Bell to finish his ideas, not—as Bell's most recent biographer insists[36]—to guarantee that Bell would obtain fortune, but because this was the second step of Faraday's charge, "work, *finish*, publish." For Henry to have been concerned that Bell would not reap financial rewards if he first published (and others would) is nonsense; in all likelihood, the matter of financial rewards never entered Henry's mind. Certainly Bell did not tell the great scientist, as he had consistently written his parents, that he sought great fortune in his work. Henry had been one of the fathers who had formulated the unwritten canons of why and how science ought to be pursued

[25] Anonymous, "The Dutch have taken Holland," *The Telegrapher*, vol. 10, pp. 169–170, July 18, 1874. The journal called attention to its own article about the physician's work with the Reis telephone.
[26] Alexander Graham Bell to his parents, November 23, 1874, Bell MSS., L.C. Bruce, *Bell*, p. 131.
[27] *Ibid.*
[28] *Ibid.*, p. 158.
[29] *Ibid.*, pp. 130, 158.
[30] *Ibid.*, p. 158.
[31] Alexander Graham Bell to George Brown (Draft), October 4, 1875, Bell MSS., L.C. Bruce, *Bell*, p. 158.
[32] Elisha Gray to A. L. Hayes, ca. March 17, 1875 (rec'd March 19, 1875), Gray MSS., Div. of Elec., NMHT.
[33] Elisha Gray to A. L. Hayes, May 7, 1875, Gray MSS., Div. of Elec., NMHT.
[34] March 1, 1875. Bruce, *Bell*, pp. 139–140.
[35] Alexander Graham Bell to his parents, March 18, 1875, Bell MSS., L.C. Bruce, *Bell*, p. 140.
[36] Bruce, *Bell*, p. 140.

in America. Seeking personal fortune was strictly forbidden. Bell's depth of scientific understanding in acoustics greatly impressed Henry.[37] For this reason, he encouraged Bell to finish his work, even when the young man protested that he did not have "the electrical knowledge necessary to overcome the difficulties."[38] If Henry had not believed that Bell could obtain that knowledge, he never would have firmly told him to "get it."[39]

During the remainder of 1875, both Bell and Gray continued to perfect their multiple telegraphs with full confidence that there were big financial rewards ahead. Now, knowing that he had a competitor, Gray became much more private in his work, and, as Bell had done earlier, he began to set his present and past accomplishments into written record. Bell, while excited about the financial prospect for multiple telegraphy, became possessed by the technical problem of voice transmission and by its possibilities as a revolutionary form of communication. His results in this area, however, would have encouraged only the greatest believer, and Bell seemed to be the only one.

VIII

For all parties concerned, the Centennial year promised to be the multiple telegraph's and telephone's most exciting—and controversial—year. Gardiner Hubbard, Bell's financial backer, started the year off with a bang when he wrote Bell from Washington regarding Bell's as-yet unfiled patent application which he hoped would nail down his multiple-telegraph ideas and his telephone ideas:

> [T]here is now much excitement in this branch of Telegraphy and you in conversation may unwittingly communicate information, which will set others on the look out. Mr. Pollok [our patent lawyer] gave me sufficient reasons to think we should lose no time in the application.[40]

Perhaps the best reason was because on that day Elisha Gray had come to town to prepare several patent applications.

While in Washington, Gray sketched out and wrote a description of a telephone transmitter and receiver. As with Bell, the technical problem of the transmission of speech had weighed on his mind over the past year and now he thought he had licked that problem. As a protective measure his lawyer drew up a caveat, which he filed in the Patent Office February 14, 1876. No longer used in patent proceedings, a caveat was an inventor's formal and confidential declaration to the Patent Office that he had an idea which he planned to perfect and turn into a patent. In theory, it protected that inventor's idea from being exploited by other inventors. Soon after Gray filed his document, he went to Philadelphia to plan what he hoped to be an impressive display of his multiple telegraph system at the upcoming Centennial Exhibition. There he received notice from his lawyer that the caveat had come into interference with a patent application, but a few days later his lawyer informed him that the interference had been dropped because the patent had been applied for before Gray filed his caveat. Now, his lawyer told him, Alexander Graham Bell held a patent on a speaking telephone. (When Gardiner Hubbard had learned that Gray was in Washington, he had ordered Bell to Washington to file his patent application.)

Gray could have contested the Patent Office's action and forced an evaluation of priority, but he did not exercise this option. Since his initial discovery, he had regarded the transmission of speech as of secondary importance to the development of multiple telegraphy. More than this, he saw speech transmission as strictly of scientific and not commercial importance. Some day in the distant future, he conceded, the telephone might have some economic possibilities; that is why he had filed a caveat rather than a patent application. For now, however, the multiple telegraph was the critical problem in electrical communications. Gray decided to drop the caveat matter in hopes of attaining an overwhelming victory over Bell with his multiple telegraph.[41]

At the time Bell filed his patent application, he had never transmitted speech, yet he held a firm conviction that the human voice could be transmitted electrically. His patent application described the devices he envisioned: for transmitter and receiver alike, an electromagnet with one of its poles placed near a piece of soft steel attached to a skin or membrane diaphragm. Bell maintained that in theory the human voice would move the transmitter's diaphragm sufficiently to generate magnetoelectric currents in the electromagnet, which would, in turn, cause the receiver's diaphragm to move in sympathy with that of the transmitter and thereby reproduce the voice.[42] Off-handedly, Bell also threw in an idea about a transmitter that would vary the resistance in a circuit in accordance with the voice and, as it turned out, this was the very essence of Elisha Gray's caveat. Somehow, after Bell filed his application, he found out that this had been the point of brief interference with Gray's caveat.[43] This seemed to spur him into trying a variable resistance transmitter, and, with this type of device, on March 10, 1876 he transmitted the human voice for the first time. However, after intensive experiments with variable resistance transmission, he dropped the method and developed magnetoelectric devices that worked much more consistently.[44]

These are only small, albeit fascinating, matters in our story; what is more important is to review Bell's course of action after he obtained positive results. Gray had seen no possibilities for commercializing the telephone but had seen great scientific merit in it. He was, however, too busy for such matters. Bell, on the other hand, could see limitless commercial possibilities for the telephone. How did he announce his accomplishment to the world? He chose to buttress his patent by first winning the blessings of the scientific community. He assembled five Harvard scientists and Edward Pickering of M.I.T. and on May 2, 1876 explained the theory of the magnetoelectric telephone and demonstrated its ability to transmit

[37] This is evident from Henry's desire to repeat Bell's electroacoustic experiments and to publish them. Bruce, *Bell*, p. 139. Also, this is in sharp contrast with what Henry thought of Gray. He told Bell that Gray, "was by no means a scientific man." Alexander Graham Bell to parents, March 18, 1875, Bell MSS., L.C.

[38] Alexander Graham Bell to his parents, March 18, 1875, Bell MSS., L.C. Bruce, *Bell*, p. 140.

[39] Bruce, *Bell*, p. 140.

[40] Gardiner G. Hubbard to Alexander Graham Bell, January 15, 1876, Bell MSS., L.C. Bruce, *Bell*, p. 165.

[41] For more details on Gray's caveat and the forces which shaped his opinion of the telephone see, D. A. Hounshell, "Elisha Gray and the telephone: On the disadvantages of being an expert," *Technology and Culture*, vol. 16, pp. 133–161, Apr. 1975.

[42] See United States Patent 174 465, reprinted in A. G. Bell, *The Bell Telephone*, pp. 451–460.

[43] For Bell's explanation, see *Ibid*, pp. 193–195.

[44] Bruce, *Bell*, p. 177. For a first rate study of Bell's experiments with variable resistance transmission, see B. S. Finn, "Alexander Graham Bell's experiments with the variable-resistance transmitter," *Smithsonian J. of History*, vol. 1, pp. 1–16, Winter 1966.

speech.[45] Eight days later, he delivered a paper on the telephone before the learned American Academy of Arts and Sciences in the Boston Anthenaeum.[46]

Bell's paper before the American Academy was a *tour de force*. About one-half of the paper is devoted to the work of prior investigators in acoustics and electroacoustics; in the other half, Bell places his work in perspective with these other investigations. He explained in detail the basic theory of the telephone—what he called undulatory currents—and then briefly recounted experiments with voice transmission:

> A friend was sent into the adjoining building to note the effect produced by articulate speech. I placed the membrane of the telephone near my mouth, and uttered the sentence, "Do you understand what I say?" Presently an answer was returned through the instrument in my hand. Articulate words proceeded from the clock-spring attached to the membrane and I heard the sentence: "Yes, I understand you perfectly."[47]

His words were cold, precise, and without emotion. Rather than pointing out any commercial possibilities, Bell went on to describe the variable resistance transmitter as an alternative to the magnetoelectric instrument. Then he classified: "The telephonic effects described above are produced by three distinct varieties of currents, which I term respectively intermittent, pulsatory, and undulatory . . . ."[48] And, as we might expect, he concluded with a word about the future. But rather than mentioning the possibility that someday people might converse between Boston and San Francisco or any such matter, Bell concluded that the currents generated by his instruments might be studied by various optical devices. Importantly, although he exhibited his telephones, he did not demonstrate them,[49] nor did he mention the fact that he had patented them.

Bell might have told this scientific audience the same thing he had recently written his father, i.e., that "the day is coming when telegraph wire will be laid on to houses just like water or gas—and friends converse with each other without leaving home"[50] or, that with his patent, "*the whole thing is mine*—and I am sure of fame, fortune and success"[51]; but he knew that such wild, rash, exuberant claims were not properly decorous in a learned scientific gathering. Bell had mastered the etiquette of science. Intelligently, he had applied science. Artfully, he had obtained the help of some of its practitioners. Perceptively, he had chosen a scientific audience to witness the great unveiling. The invention of the telephone was his and in the event that the courts would not defend him, Bell now felt confident that the American scientific community would.

Bell also knew that he had to win one more scientific feather for his cap; with Sir William Thomson at the Centennial Exhibition, he knew he had found it. A few days before his historic demonstration he wrote his fiancé, "One thing I can stand my own upon, and that is *theory*. I can *talk* and *explain* and Sir William will understand."[52] Bell was right. His historic June 25th demonstration captured the understanding, excitement, and admiration of Sir William, who, when in Boston in July, enthusiastically performed telephone experiments with Bell. The inventor graciously gave Sir William a transmitter and receiver to take back to the Old World.[53] With these, the great scientist became the herald of Bell and the telephone in Europe. At the August 1876 meeting of the British Association for the Advancement of Science, Thomson delivered an address on science in America in which he described the performance of the Bell telephone and called it "the greatest by far of all the marvels of the electric telegraph."[54]

With scientific matters secure, Bell and his associates could then proceed with popularization and commercialization, which involved lusty claims for present and future performance. Bell continued, however, to maintain relations with the scientific community by lecturing again at the American Academy of Arts and Sciences and such learned organizations, and through personal relations with various scientists.

Bell's introduction of the telephone through the scientific community confirmed Elisha Gray's initial views of it as a scientific curiosity without commercial possibilities. On several occasions in 1876 and 1877 he commented to his patent lawyers that, "As to Bell's [magnetoelectric telephone], it only creates interest in scientific circles, and, as a scientific toy, it is beautiful . . . ."[55] Gray continued the development of his eminently practical multiple telegraph. But early in 1877, Bell stepped up the pace of his public demonstrations in which he stressed the telephone's practicability. Sometime in the last half of that year (possibly after the first commercial Bell telephone was installed), Gray began to realize that the telephone might be of great commercial importance. So did Western Union officials who had always seen the telephone the same way Gray had.

In 1876, William Orton, Western Union's president, had rejected an offer from the Bell interests to buy Bell's telephone for $100 000.[56] But late in 1877, Orton and his company decided that they too wanted to enter the telephone business; characteristically, they wanted the *entire* business. Orton ordered his two electrical experts, Frank L. Pope and George B. Prescott, to survey the field and to find some means of overcoming the Bell patent. Both Pope and Prescott had long known about Gray's caveat and had urged him to fight for his rights to the invention of a variable resistance transmitter and the electromagnet diaphragm receiver. Now they thought that with Western Union's money they could turn that caveat into a patent that would destroy Bell's. Making an agreement with Gray, they moved Western Union into a showdown with Bell over who was "the inventor" of the telephone.[57]

Frank Pope, an able patent attorney as well as an expert in electricity, directed the legal preparation for Western Union. At once, he recognized that the case had to be won not only

[45] Bruce, *Bell*, p. 189. There is some question about whether this demonstration took place on May 2 or May 3. Bell's experimental notebook contains a May 3, 1876 entry which mentions experiments in John Trowbridge's laboratory at Harvard. Trowbridge was a well-known professor of physics there.

[46] A. G. Bell, "Researches in telephony," *Proc. American Academy of Arts and Sciences*, vol. 12, pp. 1–10.

[47] *Ibid.*, p. 8.

[48] *Ibid.*, p. 9.

[49] Bruce, *Bell*, p. 189.

[50] Alexander Graham Bell to his father, March 10, 1876, Bell MSS., L.C. Bruce, *Bell*, p. 181.

[51] Alexander Graham Bell to his father, February 28, 1876, Bell MSS., L.C.

[52] Alexander Graham Bell to Mabel Hubbard, June 21, 22, 1876, Bell MSS., L.C. Bruce, *Bell*, p. 193.

[53] Bruce, *Bell*, p. 200.

[54] Sir William Thomson, "Address to the Mathematics and Physics Section," in *Rep. 46th Meeting British Association for the Advancement of Science*, London, pp. 1–3, 1877.

[55] Elisha Gray to W. D. Baldwin, November 1, 1876, Elisha Gray to A. L. Hayes, November 2, 1876, Gray MSS., Div. of Elec., NMHT.

[56] Bruce, *Bell*, p. 229.

[57] D. A. Hounshell, "Elisha Gray and the Telephone," *Technology and Culture*, vol. 16, pp. 133–161, Apr. 1975.

in the courts but also in the scientific community and with the public. He seemed sensitive to the Bell company's agruments that, unlike Alexander Graham Bell, Gray had not taken the proper steps in the invention process. He wrote Gray that, "they are, or at least have been all along making a great deal of the fact that you have kept quiet and have not published or lectured . . . ."[58] They were right. Gray had not published or lectured in the same way Bell had. In the new *Journal of the American Electrical Society*, he had, however, published an article at the end of 1875 on his initial discovery of 1874 and its application to musical and multiple telegraphy. But because he was concerned chiefly with practical applications and because he viewed the telephone as a scientific curiosity, Gray only briefly alluded to the possibility of voice transmission.[59]

As Pope saw the case, Elisha Gray's development of electromagnetic diaphragm receivers was absolutely fundamental to the telephone; his work appeared to be definitive on telephone receivers. Also, Gray's variable resistance transmitter, described and illustrated in his caveat, seemed to tie down the principle of variable resistance transmission. Gray would therefore be cast in the role as the man who laid down the principles of both the transmitter and the receiver. Yet the problem in this approach stuck out plainly: Gray's failure to have published papers describing these principles in adequate detail.[60]

Pope intended to correct this failing, and, in early 1878, he launched an all-out attack designed to put Gray's name and accomplishments before both the scientific community and the public. First, he published a review of one of Bell's lectures in which he stated, in the objective tone of a scientist, Gray's claims to the invention of the telephone.[61] Then, his colleague George Prescott wrote an article on the telephone that claimed for Gray the discovery of the principles of receiving and transmitting the human voice. *Scribner's Monthly*, a popular magazine with a circulation of 100 000, published it.[62] Prescott, a well-known author of books on telegraphy, also put together a compilation of printed material on the invention of the telephone including the work of Reis, Amos E. Dolbear, Gray, Thomas Edison, and Bell, and published it as a book, *The Speaking Telephone, Talking Phonograph and Other Novelties*.[63] Prescott's introduction and arrangement of the material were designed, as a British reviewer noted, "to advertise Mr. Gray's claims to be recognized as the first and true inventor of the speaking telephone . . . ."[64] In *Popular Science*, Prescott published a biographical sketch of Elisha Gray, stating boldly in the first sentence that he was "the inventor of the Speaking Telephone."[65] And finally, Pope encouraged Gray to write an account of his work, which was published in 1878 with the title *Experimental Researches in Electro-Harmonic Telegraphy and Telephony, 1867-1876*.[66]

These publications gained for Gray almost immediate recognition from the scientific community. William H. Preece, a British telegraph expert who had shown much interest in the telephone's invention, is representative of this trend. After learning of Bell's invention from his friend and colleague William Thomson and from Bell's own accounts of his work, Preece had become a staunch defender of Bell's priority; he had called Gray and others "detractors." This could be expected since Gray had not published anything on his work, but after learning of Frank Pope's evaluation of the controversy, Preece admitted that Elisha Gray should receive scientific credit for his work.[67] Possibly he was the reviewer who wrote that, "Mr. Gray was probably the first to conceive of a theoretically correct speaking telephone . . . ."[68] Here was absolute irony. As we have seen, from 1875 until mid-1877, Gray had regarded the telephone as a matter of scientific importance, a matter he had wished to have no part of. Now, in the struggle over who would win commercial control of the telephone, Gray had gained scientific recognition. Most ironic, however, was the fact that by this time the telephone was of such commercial importance (which Gray had not anticipated) that any decision by the scientific community about who should receive full or partial credit for the telephone was now completely meaningless. The only decision that mattered was a legal one; whereas scientists allowed for codiscovery, in the eyes of patent law there could be only *one* inventor of the telephone. Also, the public wanted only one inventor. As we know, that turned out to be Alexander Graham Bell.

There are many reasons for this outcome. This paper suggests that the differences in Bell's and Gray's style of invention proved to be critical. Where Gray worked in the open, Bell chose secrecy. Where Gray, the practical electrician, never moved beyond the multiple telegraph even though he had conceived of a telephone, Bell, the speech teacher, dropped his work with multiple telegraphy to pursue what he somehow believed would be a revolutionary form of communications. Mixed in with these matters of style is the important element of science, which Bell and Gray viewed in very different ways.

For Gray, science represented a distinctly different pursuit than the one he had chosen for himself; it operated with an entirely different system of rewards for its devotees. At the time of the invention of the telephone, Gray regarded himself as a new breed of inventor who made his living through invention and technical development, a breed unlike the archetypal Yankee tinkerer.[69] If, in the course of developmental work, he discovered something of pure scientific interest, he would not seek rewards in the scientific community for that discovery. (His experience in 1874 with Joseph Henry and other scientists probably convinced him of that.) Although he would use science, Gray had differentiated his line of work—what we might call engineering—from that of science; for him,

[58] F. L. Pope to Elisha Gray, March 14, 1878, Gray MSS., Div. of Elec., NMHT.

[59] E. Gray, "On the transmission of musical tones telegraphically: experimental researches," *J. American Electrical Society*, vol. 1, pp. 3-15, Dec. 1876.

[60] F. L. Pope to Elisha Gray, March 14, 1878, Gray MSS., Div. of Elec., NMHT.

[61] *J. Telegraph*, vol. 11, pp. 65-66, Mar. 1, 1878.

[62] G. B. Prescott, "The telephone and the phonograph," *Scribner's Monthly*, vol. 15, pp. 848-858, Mar. 1878.

[63] G. B. Prescott, *The Speaking Telephone, Talking Phonograph and Other Novelties*. New York: Appleton, 1878.

[64] *Telegraphic J.*, vol. 7, pp. 101-102, Mar. 1879.

[65] G. B. Prescott, "Sketch of Elisha Gray," *Popular Science Monthly*, vol. 14, pp. 523-528, Nov. 1878.

[66] E. Gray, *Experimental Researches in Electro-Harmonic Telegraphy and Telephony, 1867-1876*. New York: Appleton, 1878.

[67] Extract of letter, George Beetle to G. B. Prescott(?), January 4, 1878, Elisha Gray MSS., Div. of Elec., NMHT.

[68] *Telegraphic J.*, vol. 7, pp. 101-102, Mar. 1879.

[69] Gray was only one of many professional independent inventors who flourished between 1870-1900. This group of men is misunderstood by historians and engineers alike. Thomas P. Hughes is the rare exception to this. His study, *Elmer Sperry: Inventor and Engineer* (Baltimore, MD: Johns Hopkins Press, 1971), takes a giant step toward understanding the "heroic" age of independent invention and the transition to the era of organized research and development.

the scientific and the technical communities existed separately. As he saw it, the engineering community gave out rewards on accomplishments, and, at the time he hit upon the telephone idea, development of a multiple telegraph was a real accomplishment with real rewards whereas the telephone was only a scientific feat. Clearly, Gray misjudged the technical and commercial importance of the telephone, a judgment that cost him both fame and fortune. This view might have been rectified had he written a scientific paper on his theory of the telephone, making no claims on the future of the device.

On the other hand, Bell—perhaps because he was not a member of either the technical or scientific community—used science and the scientific community both actively and creatively. Unlike Gray who worked out multiple telegraphy from an accidental discovery, Bell approached the multiple telegraph from the theory of sound. Helmholtz's work and Bell's scientist-friends' interpretation of it provided him with that theory, and, more important, with experimental apparatus that could be adapted to telegraphy. From acoustics and multiple telegraphy, Bell moved toward the telephone. As we have seen, he did not merely apply science or borrow from it, he also used it institutionally to establish priority in the development of his invention. He disclosed his ideas to scientists with the fully conscious but undisclosed intent of one day using them as expert witnesses in a legal dispute. While revealing ideas to scientists, there is no evidence, nor is it likely, that he told them—as he often wrote his parents—that his ultimate aim in his pursuits was fame and personal fortune. Some of these scientists freely contributed ideas to Bell on how he might improve this or that aspect of the telephone. Then, after he had achieved successful results, Bell presented his telephone to scientific bodies as an achievement of science. Because he introduced the telephone with proper etiquette, the scientific community could sanction him; he had pursued the invention "with the true spirit of a philosopher."[70] Yet only in moments of vanity did Bell regard himself as a scientist of merit or the telephone as a great scientific discovery.[71] Had the telephone been only a matter of scientific interest for Bell, he would have, it seems, worked on it in collaboration with Clarence Blake or Charles Cross. From the start, however, he had independently pursued the invention for its financial rewards, which he had sensed would be great. This is not to say that the telephone was of no scientific interest because, as Elisha Gray pointed out, it *was* "of great interest in scientific circles." Thomson's response illustrates this quite clearly. But to his great credit, Bell knew that after the novelty wore off, science would forget the telephone; if it were to be remembered, it would be as a technical and commercial development, not a scientific one. For a while, science did reward Bell with praise and honors. In the long run, it provided him with expert witnesses, support from the community, and publications.

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[70] These are the words of W. H. Preece, "On the Telephone," in *Rep. 47th Meeting British Association for the Advancement of Science*, London, pp. 36-37, 1878.

[71] Bell's biographer, Robert V. Bruce, touches on this matter of Bell's scientific abilities. Bell did have moments of vanity when he saw himself as a great scientist, but, as Bruce notes, he "took invention far more seriously than he did scientific theorizing." Bruce, *Bell*, p. 252.